



MINISTERIO DE INDUSTRIA Y ENERGIA
CENTRO DE INVESTIGACIONES ENERGETICAS
MEDIOAMBIENTALES Y TECNOLOGICAS
(C. I. E. M. A. T.)

Madrid, 16th February, 1987

Dr. CHESTER RICHMOND
Associate Laboratory Director
for Biomedical and Environmental
Sciences.
OAK RIDGE NATIONAL LABORATORY
OAK RIDGE

ADBS

6 MAR 87 9:45

det
Dear Dr. Richmond:

I am sending to you the data related with concentration of ^{241}Am in soil samples taken last november in area 2-0 and 2-1.

From these data you can get an idea about the order of contamination and how deep it is. To get an idea about the $^{239}\text{Pu} + ^{240}\text{Pu}$ contamination you can multiply those numbers by 3.

You have the radiometric map of the area with the values of X and Y. So you can identify the sample points as they are referenced in the table.

In the samples taken at the hills, where plowing never has been made, the contamination is null for more than 15 cm deep.

The size of the area with higher contamination could be about 1 hectarea (10.000 m^2) and the total 4-5 hectareas about.

Best regards to your family and other friends

Sincerely yours,

Fdo. E. Iranzo

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U. D. INDUSTRIA Y ENERGIA	
JEN	FECHA 16-2-87
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INSTITUTO DE PROTECCION RADIOLOGICA Y MEDIO AMBIENTE
U.O. DE MEDIO AMBIENTE RADIOLOGICO

M2A/PIC02/-/87

INDALO PROJECT
Contract Number: DE-GI01-82EP 12126
REPORT FOR CONTINUING ASSISTANCE FOR FISCAL YEAR
FEBRUARY 1, 1987 TO JANUARY 31, 1988

21/4/87

Dear Chet:

This is the report from
1986 which has been
sent to Tom McCraw
at the same time.

Tell me, please, any comment
about it.

Did you get answer about
confirmation to present the report
in the IIRG?

Best regards

E. IRANZO



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INDALO PROJECT

Contract Number: DE-GIO1-82EP12126

REPORT FOR CONTINUING ASSISTANCE FOR FISCAL YEAR, FEBRUARY 1, 1987 TO
JANUARY 31, 1988.

TITLE: INDALO PROJECT.

Following of the accident at Palomares since 1966

Contract number: DE-GIO1-82EP12126

This report is a submission for continuing assistance for the fiscal year.
(February 1, 1987 to January 31, 1988).

1. INTRODUCCION.

Technical and scientific activities concerning the Indalo Project during the period February 1, 1986 to January 31, 1987 have been developed as they were projected. The detailed summary of these activities will be included in the chapters related with air, soils, vegetation, population and animals.

Periodical information to the "Nuclear Safety Council" has been given on the results of our activities on the radiation surveillance program carried out in the area of Palomares.

Periodical information to the National Congress is sent by the "Nuclear Safety Council" on the radiation risk situation at Palomares area.

Press and T.V. news about cancer risk for people living and working in this area come from time to time. The area is mentioned in the news as the most contaminated by transuranides in the world. These news are interfering



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our advising talks and are growing a feeling of worries in the people.

Public relation interferences of some ecological and pacifist associations are coming from time to time also.

2. EXPERIMENTAL WORK IN THE PERIOD 1st FEBRUARY 1986 TO 31th JANUARY 1987.

Experimental work developed during this period, discussion of results and conclusions are as follows.

2.1 AIR.

Air samples have been taken continuously in station 2-1 (uncultivated hilly area), station 2-2 (cultivated area) and station P (urban Palomares center). Sampling time has been 168 hours (1 week) most of the yearly period and the air volume is about 10,000 m³ per sample. Two air samples per week were taken during the period April 12 to June 14 to have a more detailed knowledge of the air contamination by the movement of soils that took place to build a small dam for irrigation water in area 2. One hundred and eighty three (183) air samples have been taken.

One hundred nineteen (119) air samples have been processed to electroplating for ²³⁹Pu + ²⁴⁰Pu determination and all of them have been measured by alpha spectrometry.

The selection of air samples to be analyzed have been made by taken into consideration the following.

- Air samples from 1982, 83, 84, 85 and 86 must be analyzed.
- The amount of air samples to be processed is so large that it is not possible to analyze all of them in 1 year.
- It would be desirable to have a knowledge of the order of ²³⁹Pu +



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- The knowledge of $^{239}\text{Pu} + ^{240}\text{Pu}$ air concentration in station P and station 2-1 during the dam construction, specially during the excavation and earth transport and deposition, was a priority. Station P is in the urban area of Palomares; station 2-1 is about 10 m from the border of the dam.

Forty seven out of the samples analyzed were taken at station P; twelve out of them were sampled in 1983, ten in 1984, twelve in 1985 and thirteen in 1986.

Thirty out of the samples analyzed were taken at station 2-1; seven out of them were sampled in 1984, eleven in 1985 and twelve in 1986.

Forty two out of the samples analyzed were taken at station 2-2; eleven out of them were sampled in 1982, ten in 1983, twelve in 1984 and nine in 1985.

The results obtained for the samples analyzed which belong to the period February 82 to May 86 have shown the following:

Station P (urban area)

. The 81 per cent of the results were over the detection limit, $0.3 \mu\text{Bq} \times \text{m}^{-3}$ ($8 \times 10^{-3} \text{fCi} \times \text{m}^{-3}$).

. The highest concentration was $18.5 \pm 2.2 \mu\text{Bq} \times \text{m}^{-3}$ ($0.5 \pm 0.06 \text{fCi} \times \text{m}^{-3}$) in the period April 12-15, 1986.

. The average concentration during the period April 22 to May 6, 1986 (construction of the dam) was $5.9 \mu\text{Bq} \times \text{m}^{-3}$.

Station 2-2

. The 100 per cent of the results were over the detection limit, $0.3 \mu\text{Bq} \times \text{m}^{-3}$ ($8 \times 10^{-3} \text{fCi} \times \text{m}^{-3}$).



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. The highest concentration was $6,660 \pm 33 \mu\text{Bq} \times \text{m}^{-3}$ ($178 \pm 1 \text{ fCi} \times \text{m}^{-3}$) in a week of June 1984.

. The average concentration is about ten times higher than in station P.

Station 2-1

. The 93 per cent of the results were over the detection limit, $0.3 \mu\text{Bq} \times \text{m}^{-3}$ ($8 \times 10^{-3} \text{ fCi} \times \text{m}^{-3}$).

. The highest concentration was $5,402 \pm 37 \mu\text{Bq} \times \text{m}^{-3}$ ($146 \pm 1 \text{ fCi} \times \text{m}^{-3}$) in the period April 19-22, 1986.

. The average concentration during the period April 22 to May 6, 1986 (construction of the dam) was $1.139 \mu\text{Bq} \times \text{m}^{-3}$.

These values show very well the resuspension increase by big movement of soil.

The Committee of Editors of the Official Journal of Health Physics Society has accepted for publication the report on "AIR CONCENTRATIONS OF ^{239}Pu AND ^{240}Pu AND POTENTIAL RADIATION DOSES TO PERSONS LIVING NEAR Pu-CONTAMINATED AREAS IN PALOMARES, SPAIN" So this report will be published in the next months.

2.2 SOILS.

The activities carried out with respect to the soils have been the following.

2.2.1 Correlation between soil particles size and ^{239}Pu - ^{240}Pu and ^{241}Am concentration.

It has been finished the first phase of the experimental work to determine the correlation between the soil particle size and the plutonium and americium concentration. Experimental work has been made also to determi



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ne the correlation existing between $^{239}\text{Pu} + ^{240}\text{Pu}$ and ^{241}Am concentration and the mineralogical and chemical composition of the soil.

These aspects are important for evaluating the risks attending dispersion of such contaminants through atmospheric resuspension, erosion and hydrological movement.

The results of the experimental work have been included in the report "GEOCHEMICAL DISTRIBUTION OF PLUTONIUM AND AMERICIUM IN PALOMARES SOIL".

This report was presented at the "Seminar on the cycling of long-lived radionuclides in the Biosphere: observations and models", organized by the Commission of the European Communities in Madrid, from 15th to 19th of September, 1986.

The report will be published in the Proceedings of the Seminar. The most significant conclusions drawn from this experimental work are as follows.

- Plutonium and americium content and soil granulometry are directly associated (coefficient of correlation = 0,75). The maximum concentrations correspond to fractions ranging between 63 and 250 μm . Less than 15% of residual plutonium and americium contamination is associated with the fractions of particles smaller than 10 μm . The maximum $^{239}\text{Pu} + ^{240}\text{Pu}$ found in the portion smaller than 5 μm correspond to 9% in heavily cultivated soil and 3% in less cultivated soil. The maximum percentages for ^{241}Am in the same group smaller than 5 μm are analogous in less cultivated soil and somewhat lower in the heavily cultivated soil.

- The contaminants, plutonium and americium, have been found in some authigenetic iron oxides, carbonates (dolomite) and moscovite-illite. The maximum concentration were found in the iron oxi-hydroxides.



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- The plutonium-ameridium ratio calculated for the different size fractions has a mean value of 3.0 ± 0.2 in parcels 2-0 and 3-1, while for parcel 2-2 it is 6.7 ± 0.5 and for parcel 3-2 it is 7.4 ± 0.6 . This would seem to indicate greater mobilization of ameridium in the latter three parcels which could probably be related to the Eh and pH potentials of the waters in "equilibrium" with the soil, which in parcels 2-2 and 3-2 create a slightly more reducing and alkaline environment.

- The potential leaching of plutonium, estimated from the concentration measured in the maceration-elutration waters, has been found in the range $(2-21) \times 10^{-4}$ per cent of the total contents in the soil; the greater values are correlated with the most oxidized and the least alkaline soils.

- It is necessary to continue research aimed mainly at defining the mechanisms of plutonium and ameridium fixing and dispersion since, even though the dispersion factor of clays in these soils is very low (0.23), mobilization of plutonium and ameridium colloids and complexes remains unknown.

Some of the tables showed in the report are the following.

TABLE 1. MEAN CONCENTRATION OF PU AND AM IN THE SAMPLES

Radionuclide	Activity Concentration (Bq/g)				
	Parcels				
	2-0	2-2	3-1	3-2	5-3B
$^{239}_{Pu}$ $^{240}_{Pu}$	42.60	15.60	1.09	1.82	0.46
$^{241}_{Am}$	13.86	2.54	0.34	0.32	0.02
Ratio Pu/Am	3.0 ± 0.2	6.7 ± 0.5	3.0 ± 0.2	7.4 ± 0.6	41.9 ± 27.8



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TABLE 2. ACTIVITY CONCENTRATION OF $^{239}\text{Pu} + ^{240}\text{Pu}$ IN SIZE FRACTIONS OF SOILS
(Bq/g)

Parcel	Fraction μm						
	< 5	5-10	10-20	20-40	40-63	63-250	250-1000
2-0	8.55	24.57	19.83	15.48	87.28	37.13	0.98
2-2	3.13	3.09	4.68	9.33	29.16	49.88	0.05
3-1	0.53	0.59	0.43	2.24	0.80	2.54	0.02
3-2	0.86	1.12	0.59	1.46	0.39	5.48	0.08
5-3B	2.22	0.47	0.61	0.57	0.15	0.09	0.07

TABLE 3. PERCENTAGE DISTRIBUTION OF $^{239}\text{Pu} + ^{240}\text{Pu}$ IN SIZE FRACTIONS
OF SOILS

Parcel	Fraction μm						
	< 5	5-10	10-20	20-40	40-63	63-250	250-1000
2-0	2.74	6.07	3.32	7.25	21.25	59.30	0.07
2-2	2.57	1.53	1.32	7.04	18.18	59.33	0.03
3-1	8.74	6.12	2.12	31.79	3.68	47.22	0.33
3-2	7.02	4.55	5.31	7.08	0.71	74.32	0.51
5-3B	56.98	6.05	5.62	20.30	2.88	0.85	1.22

TABLE 4. ACTIVITY CONCENTRATION OF ^{241}Am IN SIZE FRACTIONS
OF SOILS, (Bq/g)

Parcel	Fraction μm						
	< 5	5-10	10-20	20-40	40-63	63-250	250-1000
2-0	2.86	6.30	6.15	7.00	29.77	30.20	0.35
2-2	0.34	0.53	0.92	1.52	4.79	8.18	0.00
3-1	0.13	0.18	0.21	0.66	0.35	0.80	0.007
3-2	0.10	0.12	0.08	0.21	0.06	1.05	0.003
5-3B	0.01	0.03	0.07	0.06	0.009	0.007	0.003



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TABLE 5. PER CENT DISTRIBUTION OF ^{241}Am IN SIZE FRACTIONS OF SOILS

Parcel	Fraction μm						
	<5	5-10	10-20	20-40	40-63	63-250	250-1000
2-0	2.82	4.79	3.17	10.07	22.28	56.80	0.07
2-2	1.68	1.61	1.59	7.03	18.32	69.75	0.02
3-1	6.82	5.97	3.34	30.17	5.25	47.94	0.51
3-2	4.55	2.78	3.95	6.46	0.60	81.34	0.32
5-3B	7.02	8.26	14.38	50.46	3.86	12.41	3.61

TABLE 6. ACTIVITY CONCENTRATION RATIO OF $^{239}\text{Pu} + ^{240}\text{Pu} / ^{241}\text{Am}$ IN SIZE FRACTIONS OF SOILS

Parcel	Fraction μm						
	<5	5-10	10-20	20-40	40-63	63-250	250-1000
2-0	2.99	3.90	3.22	2.21	2.93	3.21	2.80
2-2	9.21	5.83	5.08	6.14	6.09	6.10	8.33
3-1	4.08	3.28	2.05	3.39	2.29	3.18	2.85
3-2	8.80	9.33	7.38	6.08	6.50	5.22	8.89
5-3B	222	15.67	8.71	9.50	16.67	12.86	7.78

2.2.2 Radiation survey on subzones 2-0 and 2-1.

Radiation survey with the Harshaw Gamma Counter (model 301) and a grill of 10 x 10 meters was made last year. Another radiation survey has been made this year on the most contaminated spots to determine the existence of hot spots and their extension with a grill of 2 x 2 meters.

The surface of the area surveyed is about 5 hectares. About 1 hectarea is the surface of the area with the highest contamination. In the spots



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with higher readings the gamma exposure rate measured at 0.5 and 2.5 m high were 0.130 mR/h and 0.040 mR/h respectively.

To estimate the $^{239}\text{Pu} + ^{240}\text{Pu}$ and ^{241}Am inventory in the subzones and their distribution with depth, soil samples have been taken in thirty seven points. Each sample was forty five centimeter deep and has been divided into five portions (0-5 cm, 5-15 cm, 15-25 cm, 25-35 and 35-45 cm). So, one hundred eighty five (185) samples were taken.

Determination of ^{241}Am concentration in each of the 185 soil samples has been made so far. The results of these determinations are included in the table 7.

Determination of $^{239}\text{Pu} + ^{240}\text{Pu}$ concentration has not been made so far. It is possible to estimate the order of plutonium concentration in each sample by taken in consideration the ratio $^{239}\text{Pu} + ^{240}\text{Pu} / ^{241}\text{Am}$, which is about 3 in the subzone 2-0.

From the ^{241}Am concentration values it is possible to conclude that in very high contamination exists some spots. In the poin nº 1 has been estimated a ^{241}Am contamination of 80.6 MBq/m^2 in the first 25 cm layer of soil (density of soil layer = 1.5). This point is about 4 m away from the impact point of the thermonuclear device nº 2.

The samples taken in the hills (points number 31, 33, 35, 36 and 37) where plowing never has been made, shown americium penetration in the soil of 5-15 cm during the 21 year course from the accident.

TABLE 7. ^{241}Am CONCENTRATION IN SOILS OF ZONES 2-0 and 2-1. YEAR 1986

PUNTO	POSICION	CONCENTRATION ^{241}Am , kBq/kg				
		0 - 5 cm	5 - 15 cm	15 - 25 cm	25 - 35 cm	35 - 45 cm
1	(270.117)	167 \pm 2%	164 \pm 1%	314 \pm 1%	9.09 \pm 3%	35.7 \pm 1%
2	(300.110)	7.62 \pm 4%	5.32 \pm 2%	6.39 \pm 1%	4.23 \pm 2%	2.71 \pm 2%
3	(287.100)	232 \pm 1%	103 \pm 1%	59.9 \pm 1%	37.3 \pm 1%	120 \pm 1%
4	(330.100)	0.97 \pm 2%	0.77 \pm 3%	0.26 \pm 4%	1.44 \pm 1%	0.13 \pm 6%
5	(285.90)	21.6 \pm 1%	19.2 \pm 1%	16.2 \pm 1%	4.52 \pm 1%	1.50 \pm 2%
6	(271.90)	3.02 \pm 2%	≤ 0.009	≤ 0.010	≤ 0.010	≤ 0.009
7	(310.90)	1.85 \pm 1%	1.73 \pm 2%	4.76 \pm 1%	1.66 \pm 1%	0.47 \pm 2%
8	(297.70)	30.41 \pm 1%	49.62 \pm 1%	32.74 \pm 1%	1.55 \pm 2%	2.49 \pm 1%
9	(330.70)	0.18 \pm 2%	0.11 \pm 4%	0.18 \pm 2%	0.05 \pm 6%	0.02 \pm 17%
10	(290.50)	14.6 \pm 1%	9.58 \pm 1%	1.56 \pm 1%	2.79 \pm 1%	1.03 \pm 2%
11	(285.30)	7.32 \pm 1%	3.48 \pm 1%	0.69 \pm 2%	1.06 \pm 1%	0.38 \pm 2%
12	(290.123)	13.27 \pm 1%	20.73 \pm 1%	11.0 \pm 1%	12.9 \pm 1%	0.16 \pm 4%
13	(320.123)	0.70 \pm 2%	1.57 \pm 1%	1.13 \pm 1%	0.19 \pm 3%	0.40 \pm 3%
14	(310.145)	47.2 \pm 1%	5.14 \pm 1%	3.54 \pm 1%	0.40 \pm 2%	0.64 \pm 1%

TABLE 7. (Continuation)

PUNTO	POSICION	CONCENTRACION ^{241}Am , kBq/kg				
		0 - 5 cm	5 - 15 cm	15 - 25 cm	25 - 35 cm	35 - 45 cm
15	(250.145)	62.4 \pm 1%	43.9 \pm 1%	51.9 \pm 1%	36.3 \pm 1%	1.24 \pm 2%
16	(260.145)	7.50 \pm 1%	3.21 \pm 2%	2.25 \pm 1%	0.17 \pm 3%	0.44 \pm 2%
17	(280.160)	6.91 \pm 1%	0.94 \pm 2%	0.17 \pm 3%	0.50 \pm 2%	4.0.008
18	(300.160)	51.23 \pm 1%	172 \pm 1%	18.9 \pm 1%	3.86 \pm 1%	0.03 \pm 10%
19	(310.160)	49.0 \pm 1%	24.7 \pm 1%	12.3 \pm 1%	0.24 \pm 3%	≤ 0.014
20	(320.160)	1.65 \pm 2%	0.91 \pm 1%	0.71 \pm 1%	0.02 \pm 1%	≤ 0.010
21	(310.180)	2.51 \pm 1%	2.24 \pm 1%	23.6 \pm 1%	0.26 \pm 2%	0.06 \pm 8%
22	(300.180)	31.8 \pm 1%	6.36 \pm 1%	5.46 \pm 1%	3.48 \pm 1%	8.93 \pm 1%
23	(280.180)	6.43 \pm 1%	8.94 \pm 1%	3.45 \pm 1%	≤ 0.007	≤ 0.010
24	(285.200)	2.73 \pm 2%	0.24 \pm 2%	0.04 \pm 10%	≤ 0.006	0.07 \pm 4%
25	(300.200)	1.18 \pm 2%	1.61 \pm 1%	1.04 \pm 1%	0.14 \pm 5%	0.05 \pm 6%
26	(320.200)	6.62 \pm 1%	3.81 \pm 1%	3.01 \pm 1%	0.70 \pm 2%	≤ 0.006
27	(310.225)	15.5 \pm 1%	29.3 \pm 1%	30.0 \pm 1%	12.0 \pm 1%	0.76 \pm 2%
28	(300.225)	16.9 \pm 1%	10.1 \pm 1%	3.97 \pm 2%	3.58 \pm 2%	0.11 \pm 5%
29	(290.225)	5.33 \pm 1%	13.3 \pm 1%	0.81 \pm 2%	4.29 \pm 1%	1.56 \pm 1%



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2.3 VEGETACION.

Activities carried out with respect to the vegetation have been as follows.

2.3.1 Sampling.

Tomatoe fruits and tomatoe plants have been sampled in five green houses and in one parcel. Thirteen samples of tomatoes and thirteen of tomatoe plants were taken.

Bean fruit and bean plant was sampled in one parcel; one sample of each.

Wild vegetation was sampled in subzones 2-0 and 2-1. Thirteen samples have been taken; the samples were esparto grass, thyme, passerina, santolina and euphorbia.

Oats cultivated in subzone 2-0 have been sampled. This subzone was cultivated in 1986 because it rained in the area during the fall of 1985. The oats was harvested as green pasture for animals.

Barley was cultivated in many parcels during 1986 because it rained more than usually 20 samples of barley (grain, straw and spicule) were taken in zone 3 and zone 5.

2.3.2 Analysis.

All the 1986 vegetations samples have been treated to ashes during the same year. Each tomatoe sample has been differentiated between peel and fruit without it; the bean fruit was differentiated between seed and trifle. In one sample of esparto grass and one of a determined bush the root was also sampled. So one hundred eighteen (118) samples of vegetation ashes were prepared for analysis during 1986.



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2.3.2.1 Determination of $^{239}\text{Pu} + ^{240}\text{Pu}$.

Radiochemical analysis and counting by alpha spectrometry have been made in the six tomatoes samples taken in 1985 and in fifty eight vegetation samples (tomatoes, bean, oats and wild vegetation) taken in 1986.

Radiochemical analysis of all vegetation sampled in 1984 have been made; the alpha spectrometry counting of forty nine electroplated samples out of them is now running.

From the $^{239}\text{Pu} + ^{240}\text{Pu}$ concentration values obtained with regard to the few vegetation samples in 1985 it has been deduced that no contamination over the detection limit of our method, $0,37 \text{ mBq} \times \text{ash g}^{-1}$ ($0,01 \text{ pCi} \times \text{ash g}^{-1}$) has been measured in the samples of tomatoes fruit (peel and fruit without peel). In one of the tomatoe plant sample a contamination of $75.9 \pm 18.9 \text{ mBq} \times \text{kg}^{-1}$ has been counted.

From the $^{239}\text{Pu} + ^{240}\text{Pu}$ concentration values in vegetation sampled during 1986 it has been deduced:

- Tomatoes cultivated in green houses sohws in some samples of plants (5 samples), fruit without peel (1 sample) and peel (4 samples) contamination of $^{239}\text{Pu} + ^{240}\text{Pu}$.

The average values of these contaminations are:

Plants: 1.4 Bq/kg .

Tomatoe: 0.11 "

Peel: 0.14 "

The maximum values are:

Plants: $4.4 \pm 13\% \text{ Bq/kg}$

Tomatoe: $0.11 \pm 16\% \text{ "}$

Peel: $0.43 \pm 26\% \text{ "}$



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The tomatoes cultivated in a parcel had not contamination at any part.

- The 100% of wild vegetation samples taken at zones 2-0 and 2-1 have $^{239}\text{Pu} + ^{240}\text{Pu}$ contamination in the range 500 to 37.000 Bq/kg. The highest value has been in esparto grass, $37,126 \pm 11\%$ Bq/kg; in the root of the esparto sampled a $^{239}\text{Pu} + ^{240}\text{Pu}$ contamination of 27,901 Bq/kg has been measured.

- In the sample of green oats cultivated in zone 2-0 a $^{239}\text{Pu} + ^{240}\text{Pu}$ contamination of $604 \pm 11\%$ Bq/kg has been determined.

2.3.2.2 Determination of ^{241}Am .

Three hundred ninty two ashes of vegetation samples have been measured by the "Intrinsec Germanium Detector System" to determine the ^{241}Am concentration. The yearly distribution of samples counted was the following.

1980: 94 (103 more were measured in 1985)

1981: 96

1982: 123

1983: 79

From the measured values it has been deducted the following:

- .6.1 per cent of 1980 samples had ^{241}Am contamination over the detection limit
- .1.15 per cent of 1981 samples had ^{241}Am contamination over the detection limit
- .5.7 per cent of 1982 samples had ^{241}Am contamination over the detection limit
- .7.6 per cent of 1983 samples had ^{241}Am contamination over the detection limit

The ^{241}Am contamination has been found around the years in wild vegetation sampled in zone 2-0 and 2-1. In cultivated vegetation the ^{241}Am contamination is very sporadic and found only in alfalfa of zone 3-0 and in some tomatoe plants and leaves of trees.

The detection limit for ^{241}Am counting ranged from 4 to 15 mBq x g⁻¹
of ashes



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2.4 POPULATION

One hundred forty one dwellers of Palomares have been taken to Madrid during 1986. Forty five of these dwellers have been checked up for urine excretion, lung counting and medical examination by first time; Twenty out of them were adults and twenty five children with ages in the range 12 to 16.

2.4.1 Lung burden counting

The ^{239}Pu + ^{240}Pu lung burden counting by direct measurement with the phoswich lung counter have been below the detection limit ($\leq 814 \text{ Bq}$) for the 45 dwellers checked up by first time. Direct lung counting has not been done for the others 96 dwellers checked up during 1986.

The ^{241}Am lung burden counting by direct measurement have been also under the detection limit for this radionuclide.

2.4.2 ^{239}Pu + ^{240}Pu and ^{241}Am urine excretion

In one hundred twenty four (124) people the determination of ^{239}Pu + ^{240}Pu and ^{241}Am have not shown values higher than the detection limit ($\leq 0.37 \text{ mBq/day}$).

One person showed ^{239}Pu + ^{240}Pu and ^{241}Am urine excretion over the detection limit; their excretion values were $1.85 \pm 0.12 \text{ mBq/d}$ and $3.7 \pm 0.3 \text{ mBq/d}$ respectively.

Seven people(7) have shown ^{239}Pu + ^{240}Pu urine excretion over the detection limit; the highest value has been $9.9 \pm 1.0 \text{ mBq/d}$. Two out of them have been checked up by first time. Another two were positive in previous analysis also. Three people had not positive excretion in the analysis made in previous years.



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Six (6) people have shown ^{241}Am urine excretion over the detection limit; the highest value has been $4.1 \pm 0.4 \text{ mBq/d}$. Five of these people had positive plutonium urine excretion in analysis made in previous years. The other person has been checked up by first time.

Six (6) children were born in Palomares during 1985; five out of them were boys and one was girl.

Five (5) people have died during 1985; three out of them were females and two were male. Four of them were older than 84. Not any of them died from cancer.

Six hundred forty six dwellers of Palomares have been checked up at least once for plutonium internal contamination and medical examination so far.

2.5 ANIMALS.

Two goats have been bought. The goats have been grazeing around the Palomares area by several years in a flock. The goast will remain in the flock and plutonium and americium determinations of their milk will be made this year.

Snails have been sampled in six zones of Palomares. Shell and body have been separately analyzed in samples of zone 2-0 and 2-1 which are the most contaminated. Analysis of the ensemble has been made in the other four samples.

The $^{239}\text{Pu} + ^{240}\text{Pu}$ concentration values are shown in table 8.5. From these values it is concluded that a strong relation between snails and soil contamination exist. The shell contamination is small in relation with the body contamination.



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TABLE 8. ^{239}Pu - ^{240}Pu CONCENTRATION IN SNAILS

ZONE	$^{239}\text{Pu} + ^{240}\text{Pu}$ CONCENTRATION Bq/kg.		
	SNAIL	SHELL	BODY
2-0	726	18.98	3,559
2-1	15,170	32.15	49,279
2-2	463		
5-1	46.55		
3	31.10		
Casa Marqués	3.40		

3. EXPERIMENTAL FUTURE WORK FOR 1967

Continuing the experimental work on the environmental and personal radiation surveys which have been carried out in the Palomares area on the five objectives established from its inception in 1966. The planned experimental works for 1967 are particularized in each one of the following sections.

We want to repeat once more that we are open to suggestions for research and studies on any aspect of the program considered interesting in relation with our objectives or with other objectives related with the situation in the area.



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3.1 AIR.

Air activities to be carried out are related with continuing studies on ^{239}Pu + ^{240}Pu and ^{241}Am air contamination in the area.

The following activities will become fulfilled:

- About one hundred and fifty six air weekly samples will be taken during the year at sampling stations P (village), 2-1 and 2-2.

- Cascada impactors will become installed in sampling stations P and 2-2 as soon as they would be received, to determine the ^{239}Pu + ^{240}Pu and ^{241}Am correlated with some aerosol particle sizes.

Fifteen days will be the sampling period in air stations with the cascada impactors. The number of air samples during the year mentioned in the above paragraph, will be modified according to the new sampling period and the number of samples per period at each station.

- The resuspension risk during plowing operations in some of the more contaminated cultivation field would be estimated. This estimation has not been made during 1986 because it was made the estimation of resuspension risk during the soil digging, leveling and other operations to build an irrigation dam in the area 2 of Palomares.

- One hundred twenty air samples will be processed and measured by alpha spectrometry to determine the ^{239}Pu + ^{240}Pu concentration. The analyzed samples will be selected specially from those taken in 1986 and those taken in 1987 by the cascada impactor. Air samples from 1984 and 1985 will be analyzed if possible.

Air samples taken for plowing resuspension risk estimations will be also analyzed for ^{239}Pu + ^{240}Pu concentrations if would be taken.



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- Eighty out of the air samples analyzed for ^{239}Pu + ^{240}Pu concentration will be processed and measured by alpha spectrometry also to determine the ^{241}Am concentration. The liquid effluent from the other plutonium analysis will be estoraged for ^{241}Am determination as soon as it would be possible.

3.2 SOILS.

Activities to be carried out with respect the soils will be as follow:

3.2.1 Continuing studies on the evolution of ^{239}Pu + ^{240}Pu and ^{241}Am contamination.

- Five centimeter deep surface soil samples will be taken in parcels 2-1, 2-2, 5-1, 5-2, 5-3B and into the green houses built on parcels 3-1 and 3-2. The total amount of samples will be sixty three.

- Surface soil will be also sampled in gardens and no cultivated parcels located in the urban area. About ten samples will be taken.

- The one hundred eighty five soil samples taken in thirty seven points of the subzones 2-0 and 2-1 in 1986 will be processed and measured by alpha spectrometry to determina the ^{239}Pu + ^{240}Pu concentration.

From the obtained results the inventory of ^{239}Pu + ^{240}Pu will be estimated.

- The seventy three surface soil samples taken in 1987 will be measured by the "Intrinsec Germanium Detector System to determine the ^{241}Am concentration.

The same seventy three surface soil samples will be processed latter on and measured by alpha spectrometry to determine the ^{239}Pu + ^{240}Pu concentration.



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- Determination of ^{241}Am concentration will be made in one hundred forty two surface soil samples taken in both 1977 and 1979.

Determination of ^{241}Am concentration will be also made in three hundred fifteen soil samples taken in parcels 2-1, 2-2, 3-1, 3-2, 5-1, 5-2 and 5-3B in 1969.

3.2.2 Penetration of plutonium and americium in soils.

A estudy of the penetration of plutonium and americium below the 45 cm cultivable layer of soil in some of the farming parcels it has been projected.

The inventory of ^{239}Pu + ^{240}Pu and ^{241}Am down to 1 meter will be made in one point at least of each one of the seven parcels under study since the accident.

3.2.3 Geochemical distribution of plutonium and americium in soils.

Continuing the studies on correlation between particle size and mineralogical composition with plutonium and americium concentration, a research project has been initiated to go deeper in this theme.

The experimental work will be made with soil samples taken during 1986 in subzone 2-0 and 2-1 which are the most contaminated.

The studies to be made will be come related with:

- Correlation between plutonium and americium concentration and particle size at different depth levels to conclude about the mechanisms of distribution and binding.



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- Correlation between mineralogical composition and plutonium and americium concentration. Determination of the type of binding between each mineral and plutonium and americium.

- Studies on the possible neoformation of iron oxides with plutonium.

Studies on plutonium-iron coprecipitation from the nitric solution of plutonium contaminated soil.

- Speciation of plutonium in Palomares soils to determine the fraction binded to minerals, the fraction free as plutonium oxides and the fraction soluble by irrigation water.

3.3 VEGETATION.

Activities to be carried out with respect to vegetation are as follows:

3.3.1 Continuing studies on the risk of plutonium and americium contamination of vegetation growing in the area.

Tomatoe fruits and plants will be sampled in the green houses built on contaminated parcels 3-1, 3-2 and 2-2 and in another three contaminated parcels of zone 2 and zone 3.

- Counting by alpha spectrometry will be made of forty nine electroplated samples of those taken in 1984.

- Determination of ^{239}Pu + ^{240}Pu will be made in the twenty samples of barley which have been taken in 1986. Grain, straw and spicule are the three separate components of each sample. The determination include procesing and alpha spectreomtry counting.



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- Determination of ^{239}Pu + ^{240}Pu contamination in the vegetation sampled during 1987 will be made.

- Ashes of vegetation samples will be directly counted with the "Intrisecc Germanium Detector System" to determine the ^{241}Am contamination in the vegetation sampled during 1984, 1985 and 1986. One hundred eighteen are the total samples of these three years.

Determination of ^{241}Am would be made in vegetation sampled during 1987 if time allows it.

- Determination of ^{239}Pu + ^{240}Pu and ^{241}Am contamination of stems leaves and roots of annual vegetation growing in subzone 2-0 and 2-1.

- Autoradiographical determination of plutonium and americium location in vegetation.

To determine the location of plutonium and americium in the roots, stems and leaves of some bushes which have been growing in subzones 2-0 and 2-1 by several years a study by alpha autoradiography will be done on some typical bushes of the area.

3.4 ANIMALS.

The main objective is to evaluate the plutonium and americium internal contamination of animals potentially constituent of the Palomares people diet.

Rabbits, chickens and hens feeded with vegetation growing and cultivated in the contaminated area will be selected. The ^{239}Pu + ^{240}Pu and ^{241}Am concentration will be determined in their organs and bones.

The ^{239}Pu + ^{240}Pu and ^{241}Am secretion in milk will be determined in several samples taken along the year from the two goats which have been grazing in the area several years and were bought last year.



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Milk from some of the small dairies in the area will be sampled to determine ^{239}Pu + ^{240}Pu and ^{241}Am concentration in it if any.

3.5 POPULATION

The main objective is the periodical and direct control of plutonium and americium internal contamination on people living in the area.

About one hundred fifty people will come to Madrid during 1987 for medical checking up and plutonium and americium internal contamination measurements.

People have been selected whereas the following objectives:

- To get more urine excretion data for people with previous positive results, in order to confirm the internal contamination and to confirm or to correct the committed effective dose equivalents estimated for them so far.
- To sample some of the already checked people which have been classified as without internal contamination. For the selection a special attention will be given to those persons considered as more significative from the point of view of their working activities, living and working location. It will also paid attention to those persons with previous rejected values of plutonium urine excretion in consideration of their potential external contamination.
- To check the people who has not been checked so far; priority will be given to the youngest ones.

The Epidemiological Study of Palomares Population will be started finally by the Direction General of Public Health, Ministry of Health and Consumption of the Central Government.



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4. EQUIPMENT REQUESTED.

Equipment requested to be supplied during this fiscal year to complement some of the existing equipment and to substitute those which are out of service because their age, are the following:

- A meteorological Station to measure direction and speed of winds at least; the system must be arranged with a computer to process the data and to obtain their values directly. It will become installed at the urban center of Palomares (air station in the J.E.N. home to substitute the old one which is out of service).

- The computer codes disk to estimate the committed dose equivalents to people on account of acute and chronical plutonium inhalation and ingestion exposure from the plutonium excretion data along the time.

- Computer codes to estimate the committed dose equivalents to people on account of acute and chronical americium inhalation and ingestion exposure from the americium urine excretion data along the time.

To discuss these codes and to be trained on it use the stay in Oak Ridge of one of our experts for one or two month would be very useful.

- A Germanium Detector System to substitute the old one assembled at Los Alamos National Laboratory for soils and vegetation measurements.

- The Alpha Spectrometry System with 8 dual detector units, Multi channel Analyzer and microprocessor control that was approved and bought for last year but has not been received so far.

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5. BUDGET.

The estimated total budget for the Project during the Spanish Fiscal year, January 1, 1986 to December 31, 1986 amount to 100.279.000 pts. (783,430 \$). This budget include the cost of Personnel, Overheads, Supplies, Equipment, Travel and Per Diem. The specification of each heading are in Table 9. Total economical provisions foreseen for special studies are also include in Table 9. Special studies are those on "Geochemistry of plutonium and americium in soils", "Especiation of plutonium in the soils" and "Epidemiology".

The funds from the U.S.A. Government for the Indalo Project (CONTRACT NUMBER DE-GI01-82 EP 12126) for the fiscal year February 1, 1987 to January 31, 1988 should be 500,000 \$ as it was requested in our letter to Mr. Tom McCraw dated October 1, 1986.

6. RESEARCHERS.

The main participating scientific researches in this Project during 1986 have been the following:

Emilio Iranzo, C. Emma Iranzo, Asunción Espinosa, Santiago Castaño, Angel Bellido, Enrique Mingarro and Pedro Rivas.

Ten technicians have participated also in the Project.

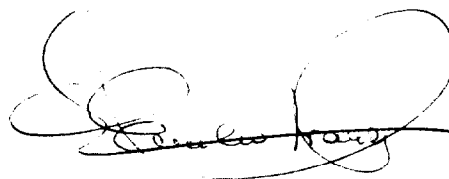


TABLE 9. INDALO PROJECT BUDGET FOR 1987

C O N C E P T	C O S T S, kpts.				
	T O T A L	C O M P O N E N T S			
		P E R S O N N E L	O V E R H E A D S	S U P P L I E S	E Q U I P M E N T
PEOPLE					
Radiological Analysis	9,032	2,723	4,085	508	1,716
Medical Survey	5,852	1,859	2,789	292	912
ENVIRONMENT					
Soil Analysis	11,060	2,737	4,106	1,118	3,099
Air Analysis	5,048	1,593	2,390	518	547
Vegetation Analysis	4,440	1,185	1,778	341	1,136
Animal Analysis	6,042	1,600	2,400	486	1,556
Water Analysis	182	61	92	18	11
Soil Sampling	367	143	214	10	
Air Sampling	744	261	391	52	40
Vegetation and Animals Sampling	1,333	521	782		
Other activities	782	313	469	30	
MANAGEMENT, ADMINISTRATION, REPORTS, etc.	37,948	15,179	22,769		
ITSx0,8; ITSx2,7; ITSx0,9					
PALOMARES HOUSE AND EQUIPMENT MAINTENANCE	1,549		1,549		
TRAVEL AND PER DIEM					
Palomares people	5,500	5,500			
J.E.N.	1,800	1,800			
Others	600	600			
SPECIAL STUDIES	8,000				
..	100,279	36,075	43,814	3,373	9,017